Optical properties of the crystal violet dye thin film

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Abstract

Thin films of crystal violet were prepared using dipping method. The optical properties have been investigated in the spectral rang (300-800 nm) . The analysis of the spectral behavior of the absorption coefficient α indicate that the fundamental absorption edge arises due to an allowed indirect transition at 1.55 eV assisting phonon of 0.13 eV is also observed.

Kay word : organic dye, crystal violet, thin film, optical properties.

الخلاصة

تم دراسة طيف الامتصاصية لأغشية رقيقة من صبغة الكريستايل فايوليت الصناعية مرسبة على الزجاج عند درجة حرارة الغرفة في مدى الأطوال الموحية المحصورة بين 300 الى 800 نانومتر . حللت نتائج الطيف ضمن أطار نظرية باردين وعينت فجوة الطاقة الناتجة من انتقال غير مباشر عند 1.55 ev وطاقة الفونون 0.13 ev

Introduction

Originally, a dye was defined as an organic compound (i.e., one that contains the element carbon) that emitted a brilliant color when exposed to visible light. This color could be imparted to other materials such as cloth, which was then said to be "dyed." Today this definition has been broadened to include hundreds of organic compounds with certain chemical ingredients and behavior in absorbing and emitting light. Thus, for example, dyes may be colorless and may absorb and emit not only in the visible spectrum but also in the ultraviolet and near infrared.

Crystal violet (CV) is try-aryl-methane dye which chemical structure shown in fig.(1) .It is used as acidic-base indicators and stain compounds in histology .It one of the fluorescent dyes which absorb and emit light in the visible region of spectrum .(M.oritiz)use CV as photosensitive material which make clear,colorlessto norland optical adhesive (NOA^{65}) photo polymerized polymer sensitive to visible region of the electromagnetic spectrum and (Cremurs,D.A,1977) use CV in dye laser. The optical investigation of thin film of this dye constitutes an important tool to enhance its applications in optical filter, display device and solid state photovoltaic cell (G.A.Chamberlain,1982).

The aim of this paper was to obtain the energy position of the fundamental absorption edge for thin film of crystal violet dye.

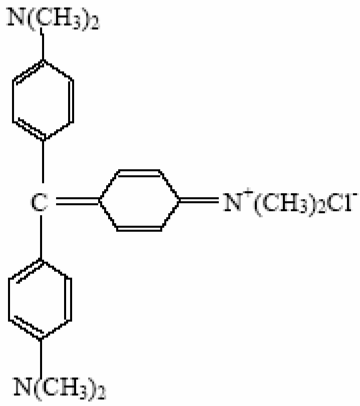

Fig.(1)

Experimental

Thin films of commercial crystal violet dye (different thickness}were obtained by dissolving the crystal violet powder in ethanol followed by dipping a clear dray glass sheet in solution .Soak the glass sheet in the solution for a few minutes and then take the sample to dried under vacuum for one hour.

The spectroscopic measurement (transmittance of films) was carried out at room temperature by means of a PYE-unicam sp-100 spectrophotometer with a glass sheet substrate as a reference.

Results and discussion

Transmittance T through a weakly absorbing slab of reflectivity R, thickness d and absorption coefficient α in air is given by (C.Y.Y.Hanna; A.K.Abass,1992)

$$T = \frac{(1-R)^2}{e^{\alpha d} - R^2 e^{-\alpha d}} \qquad (1)$$

Where

is the refractive index. In the region of band to band transition,. $R = \frac{(n-1)^2}{(n+1)^2}$ $, n$ absorption is large, so that. $e^{\alpha d} \gg R^2 e^{-\alpha d}$ .The transmittance equation becomes

$$T = (1-R)^2 e^{-\alpha d} \qquad (2)$$

The absorption coefficient is written as

$$\alpha = \frac{2.303}{d}\left(A + \log(1-R)^2\right) \qquad (3)$$

Where A is the absorbance $(A = -logT)$.

Fig(2) shows a schematic diagram for absorption spectrum for CV film of different thickness .The most interesting features which were observed in the spectrum is the main absorption peak at 570nm as noticed by (Ivo M.Raimundo Jr., R.Narayanaswamy,1999)and (Jordan Del Nero; Andre Galembeck, 2003) which described the optical properties of CV film .

The absorption coefficient of tow films were estimated after correction for the reflection losses. The long wavelength tail of the absorbance spectrum (the wavelength independent part of the absorbance) extended to the short wavelength side. The correction for reflection losses was made by subtracting the extended straightline portion from absorbance . The method of correction of reflection losses had been employed earlier and is reasonably justified(A. K. Abass,etal ,1985) .The equation (3) will be:

$$\alpha = \frac{2.303}{d} A' \qquad (4)$$

Where ($A' = A + \log(1-R)^2$).

Fig(3) show the dependence of absorption coefficient on photon energy at room temperature of tow films .For tow curves the absorption edges were appeared at about 1.96 eV , that was generally been interpreted in terms of π-π* excitation between bonding and antibonding molecular orbital's(A. Ampily, C. S. Menon, 1999).

At a low absorption coefficient ($\alpha \leq 10^4 cm^{-1}$).The absorption data were analyzed in terms of the theory of phonon assisted indirect electronic transition (Y.Ramadin,etal,1996). According to this theory the absorption coefficient depends on the photon energy hυ as (J.Bardeen,etal,1956).

$$\alpha = \frac{A(h\nu - E_g \pm E_p)^2}{h\nu} \qquad (5)$$

Where

A is constant

E_g is indirect band gap

hν photon energy

E_p the energy of the absorbed (+) or emitted (-) phonons .

The plot of $(\alpha h\nu)^{1/2}$ versus photon energy for the two CV films is given in fig.(4) .Two straight lines portions are seen in the plot for two CV films (t=4 µm and t= 55 µm). The portion at lower energy is due to transition assisted by phonon absorption and phonon energy intercept at $E_g - E_p$ .The other line corresponds to the phonon emission process and the phonon energy intercept at $E_g + E_p$.

From the energy intercepts it is found that the average indirect band gap energy E_g is (1.55 eV) and the phonon energy is (0.13 eV).The phonon energy is too high to considered as lattice phonon and it may be suggested that the observed structure of fig.(4) can be attributed to the internal vibrational groups of molecules or may be related to the existence of two valence bands(C.Y.Y.Hanna; A.K.Abass,1992).

Conclusion

The optical band gap of organic thin film was investigated .The studies on the thin film revealed that the nature of the electronic transition from valance band to conduction band is indirect transition. In this paper we have reported a simple and raped method for the deposition of crystal violet thin films on glass substrates which needed for new low-cost, lightweight, flexible thin-film solar cells based on abundant and easy-to-process organic materials. The transparent colored films have a very good optical quality which can be used very well for optical filters.

References

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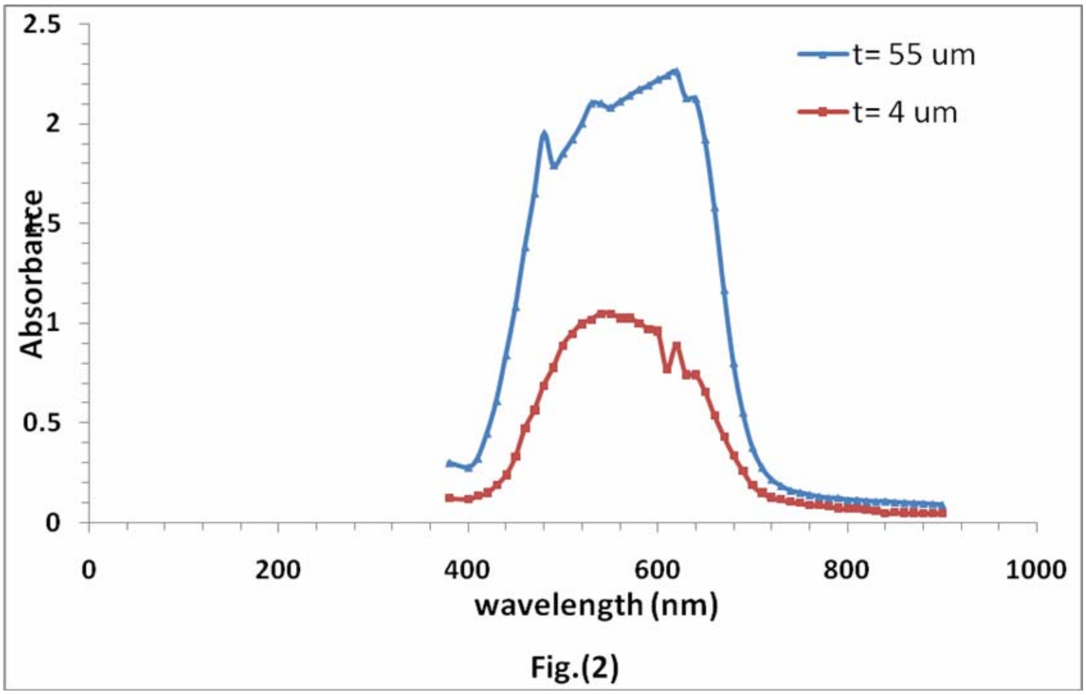

t= 55 um
t= 4 um
Absorbance
0
0.5
1
1.5
2
2.5
0
200
400
600
800
1000
wavelength (nm)

Fig.(2)

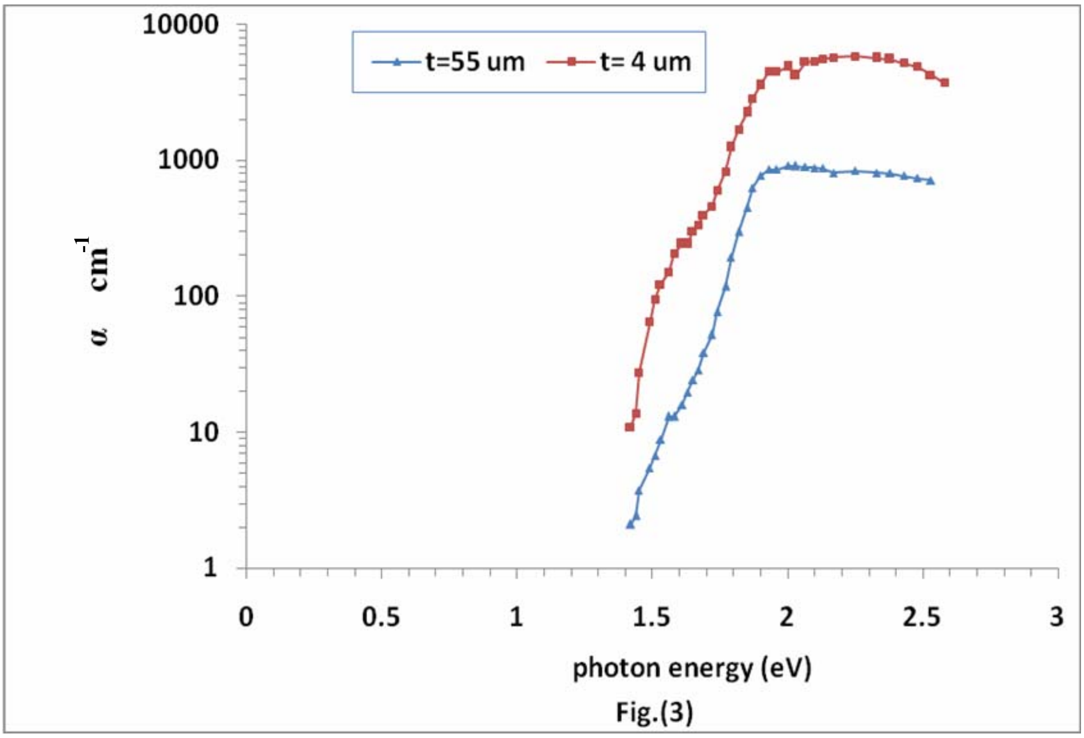
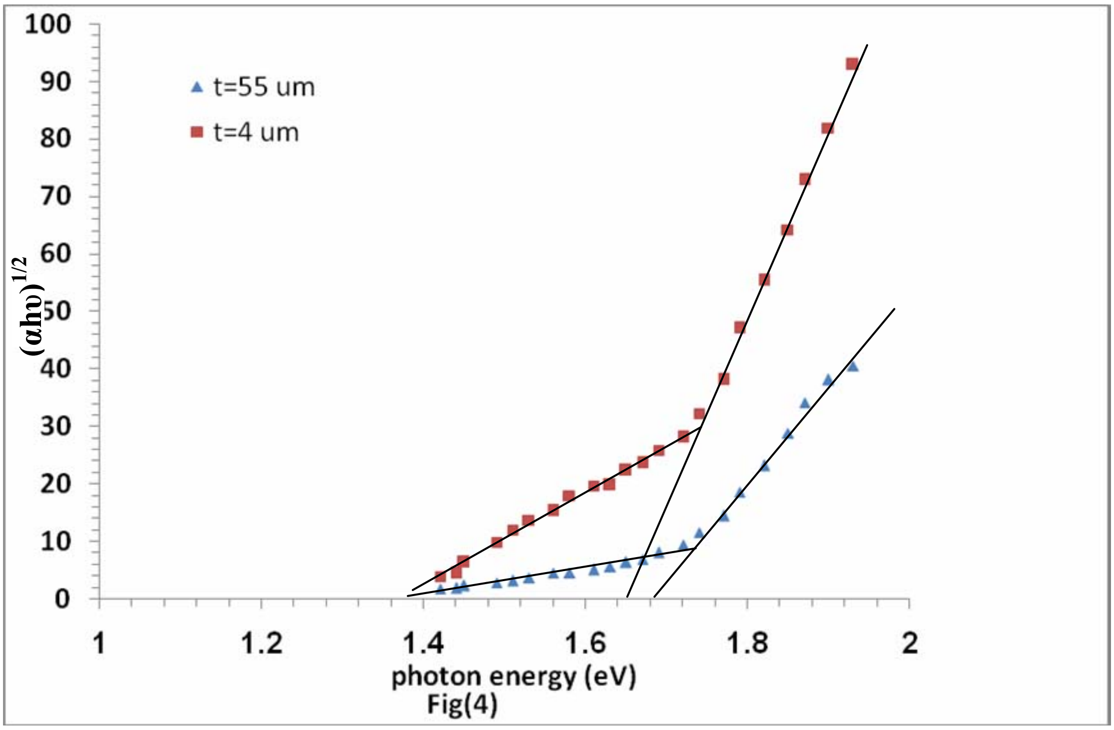

t=55 um
t= 4 um
α cm⁻¹
1
10
100
1000
10000
0
0.5
1
1.5
2
2.5
3
photon energy (eV)

Fig.(3)


t=55 um
t=4 um
$(\alpha h\nu)^{1/2}$
100
90
80
70
60
50
40
30
20
10
0
1
1.2
1.4
1.6
1.8
2
photon energy (eV)

Fig(4)